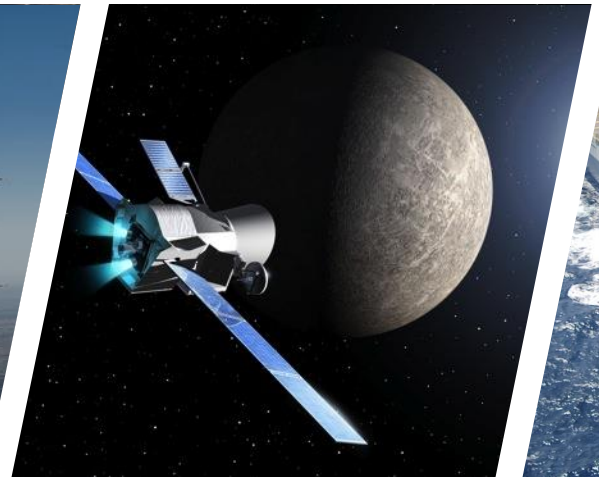
TERMA
ALLIES IN INNOVATION

Spacecraft Monitoring & Control Systems

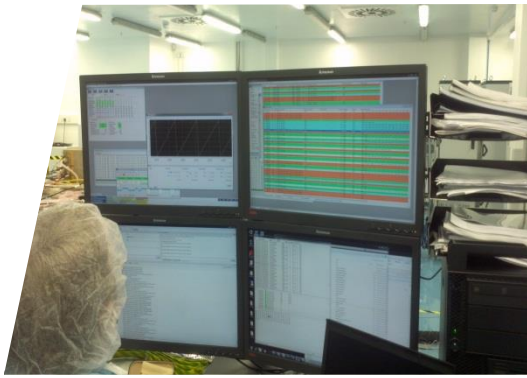
TSC & CCS - Presentation, May 2015

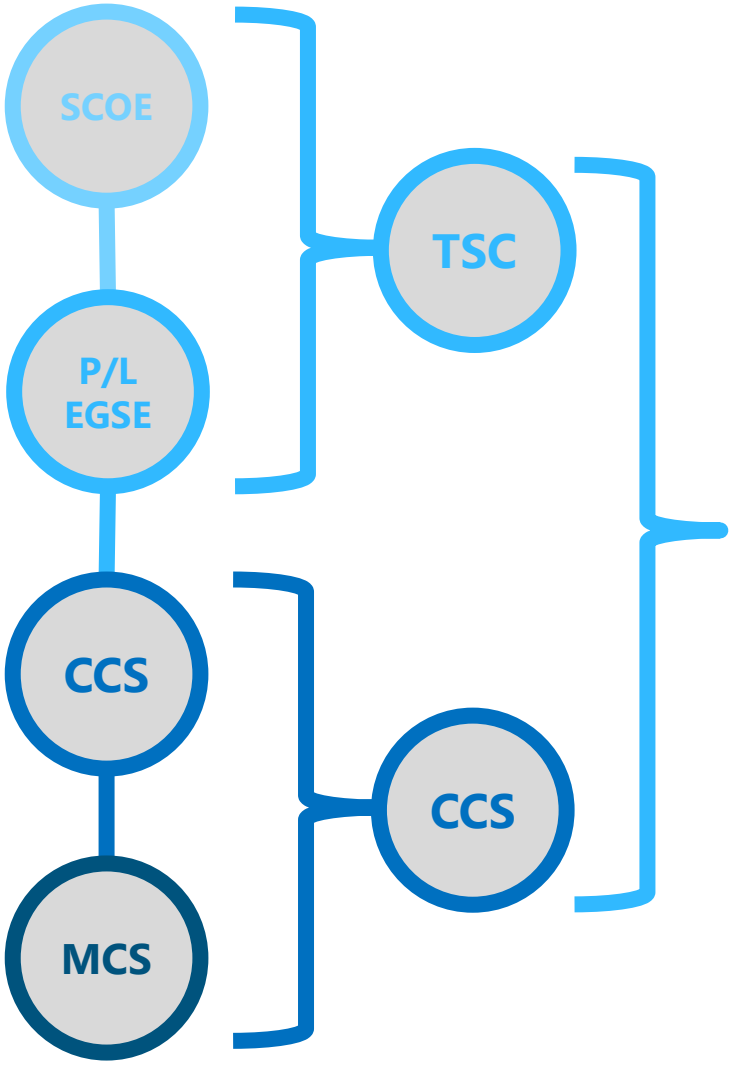
CCS

http://ccs.terma.com



SATELLITE CHECKOUT & OPERATIONS





Unified Monitoring & Control

- data model…
- procedures…
- displays…
- archives…

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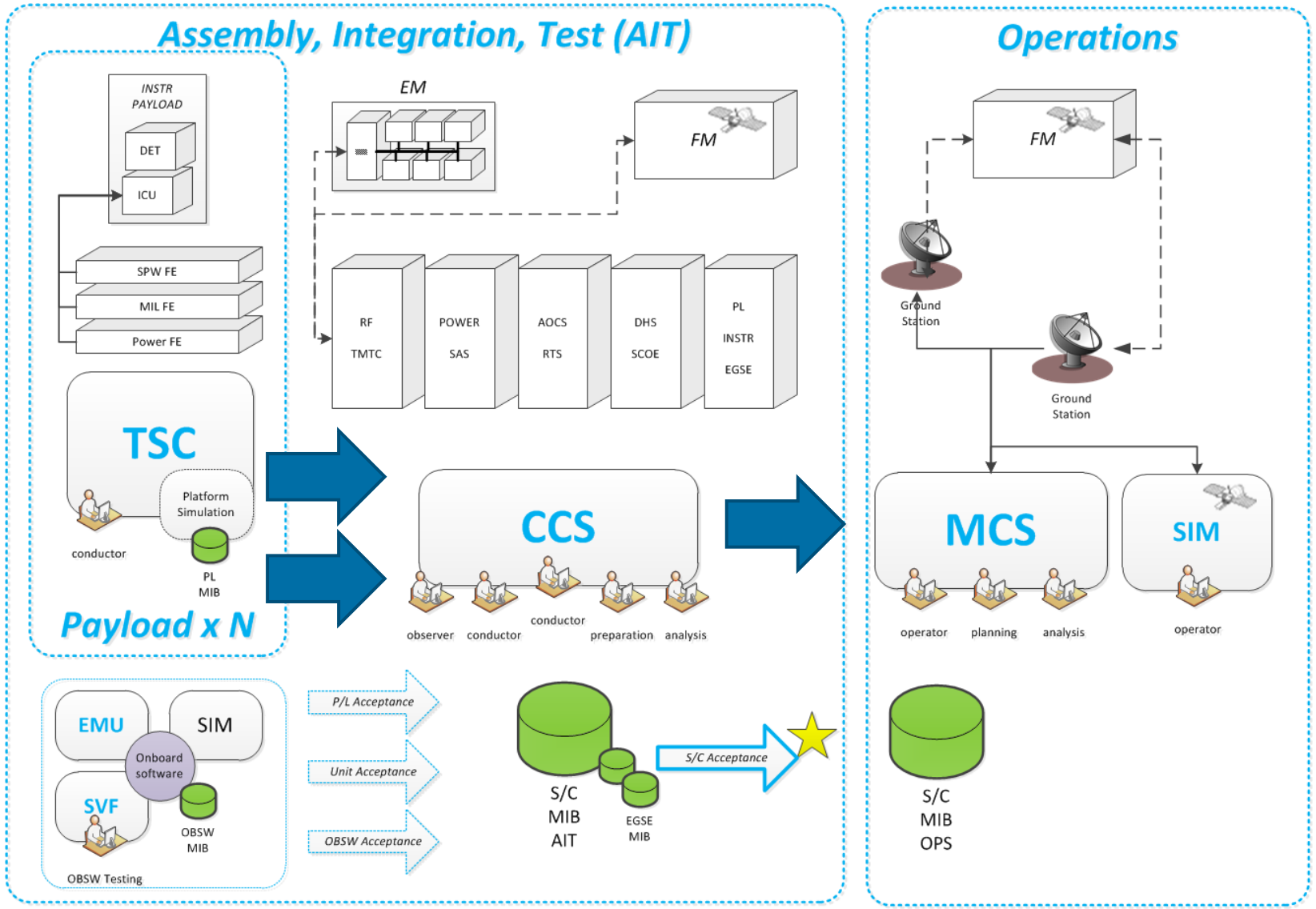
TESTING FOR OPERATIONS



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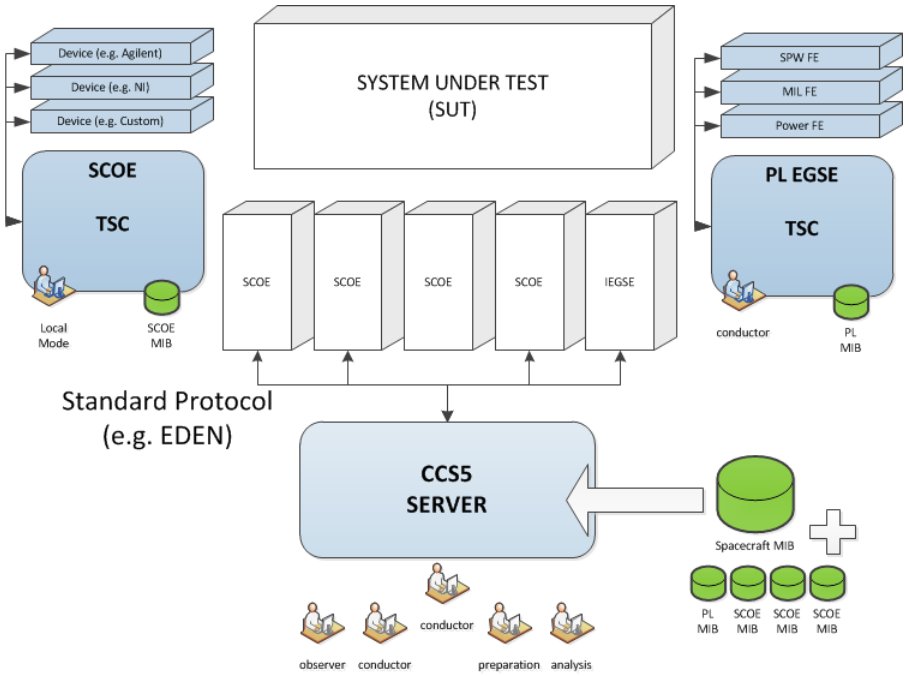
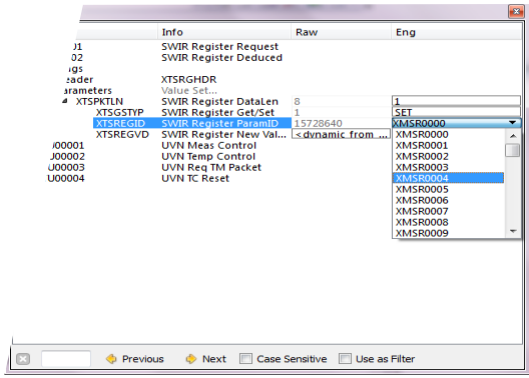
NEW TECHNOLOGY

- **Standard compliant:**
  - CCSDS/ESA/ECSS TMTC
  - ESA SCOS2000 MIB
- **Both products (CCS and TSC) use same technology**
  (based on QT, a portable SW toolkit for C++)
- **Plugins for different mission protocols**
  (prime chooses protocol for a mission)





New MMI & Features
Higher Performance
Better PUS Support

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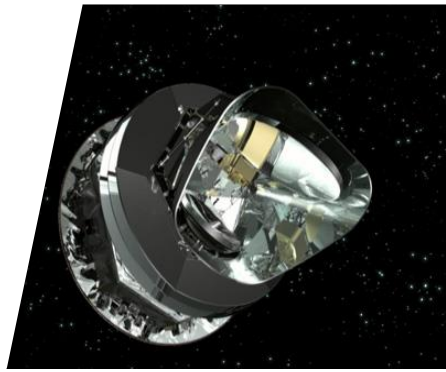
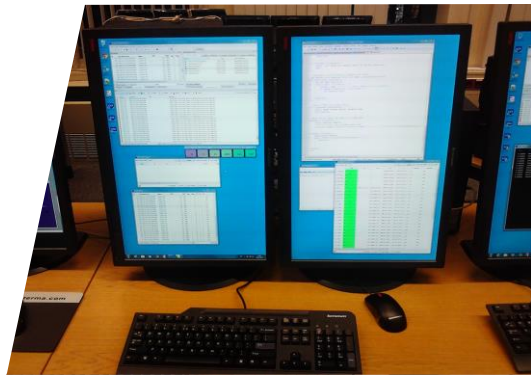
HISTORY





Concept: Compatibility between AIT & Operations:
Successful in several missions (e.g. SCOS2000)

But: with SCOS2000 and similar
- *maintenance increasingly expensive*
- *flexibility not enough for new missions AIT*
- *performance not enough for new missions AIT*

Assuming:
- ESA will use SCOS2000 for operations until EGS-CC available
- Primes continue to deliver SCOS2000 compatible MIB
- Primes & payload suppliers want to work efficiently

***Decision*: develop new <u>compatible</u> products for AIT**
- TSC = single user
- CCS = multiuser

Products:
- ***TSC for payload***
- ***CCS for platform***

Same Technology

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PORTABLE

Automated daily build & test:

Platforms

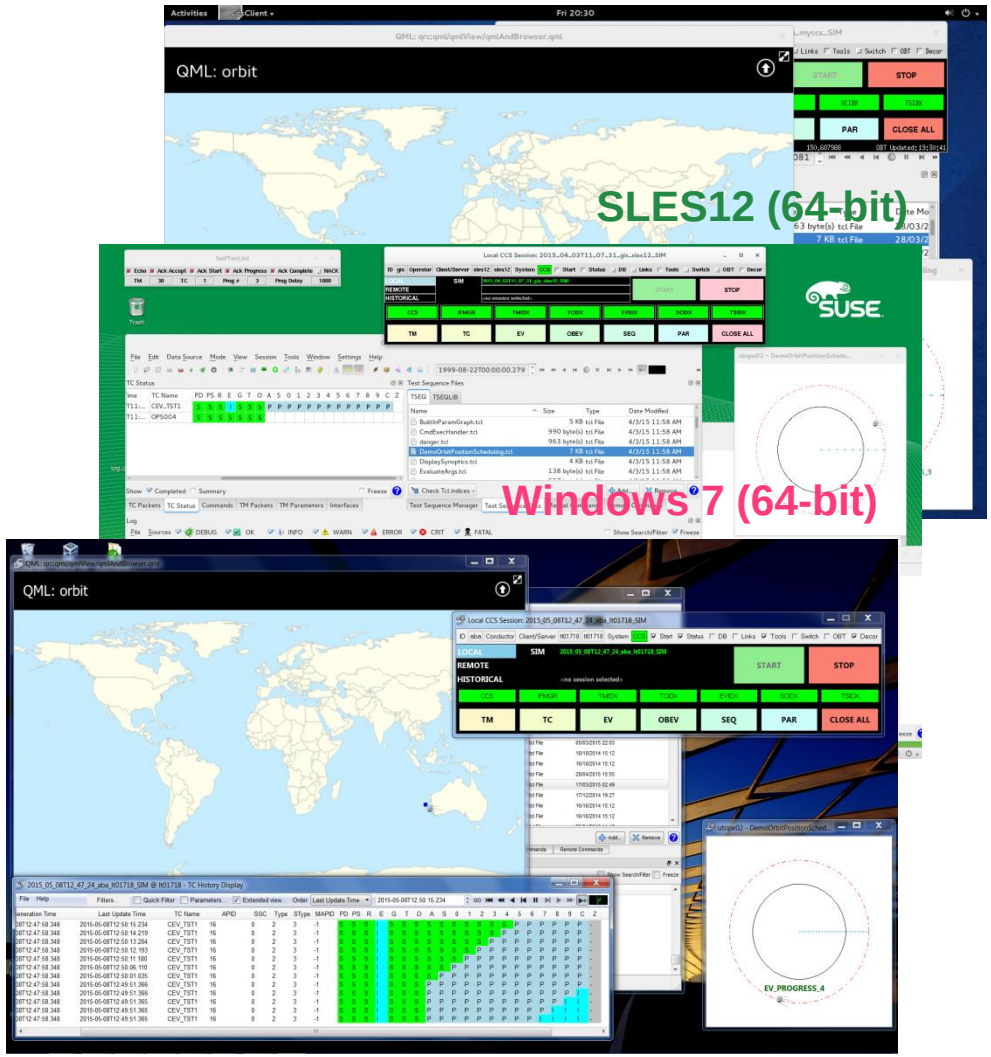
- Windows 32/64 bit
- LINUX (RHEL) 64 bit

A human-operated test is performed and formally recorded at least every 3 months.

Windows 7 is the default formal test platform.

Other distributions can be built. Automated build & test support for specific distributions can be added - at extra cost.

Note: some plugins are inherently only available on specific platforms, e.g.: CMDVS (32-bit Windows only)



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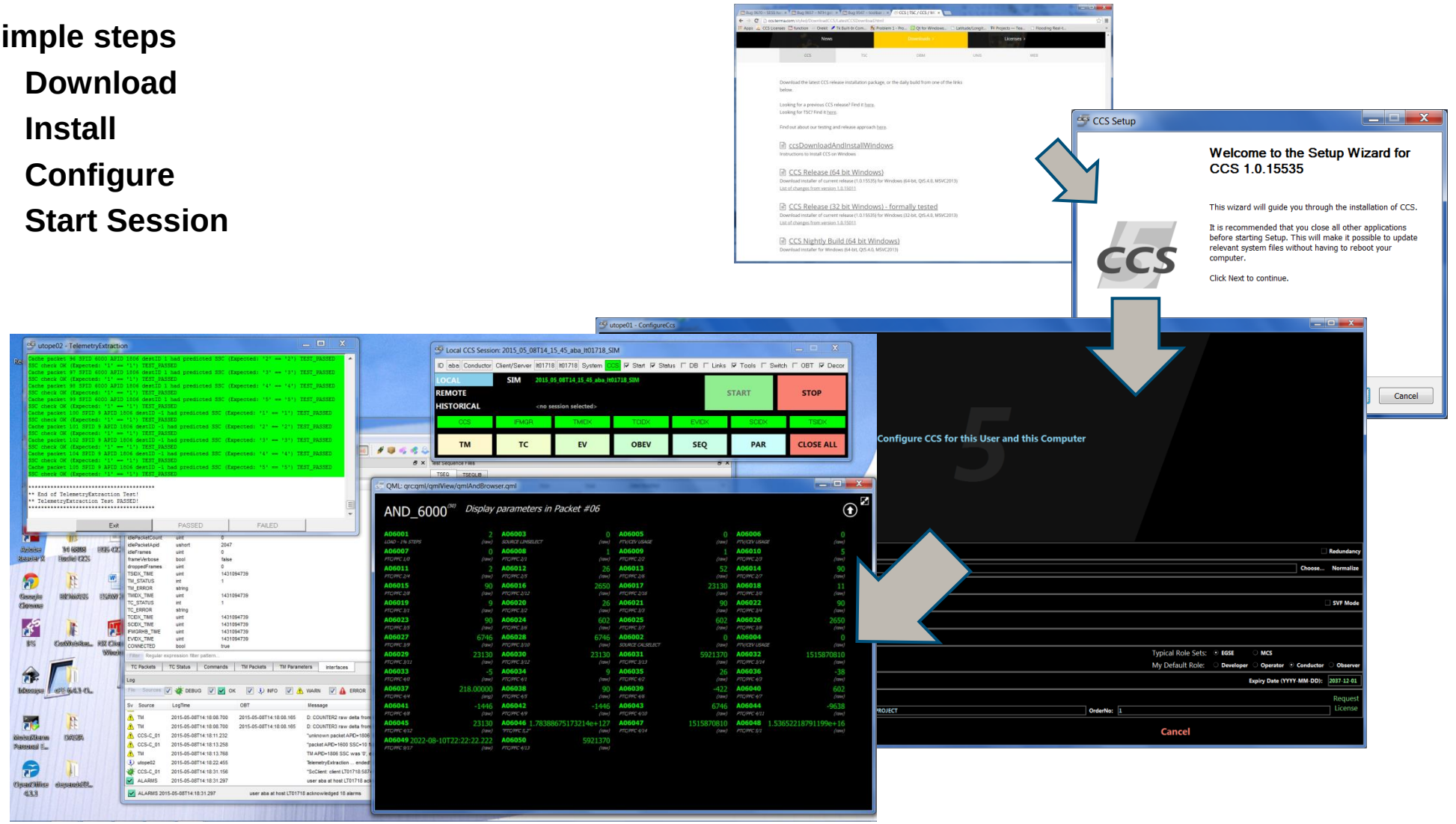
EASY TO INSTALL & SET UP

Simple steps

- **Download**
- **Install**
- **Configure**
- **Start Session**



MODERN USER INTERFACE

Based on Qt5 and QML

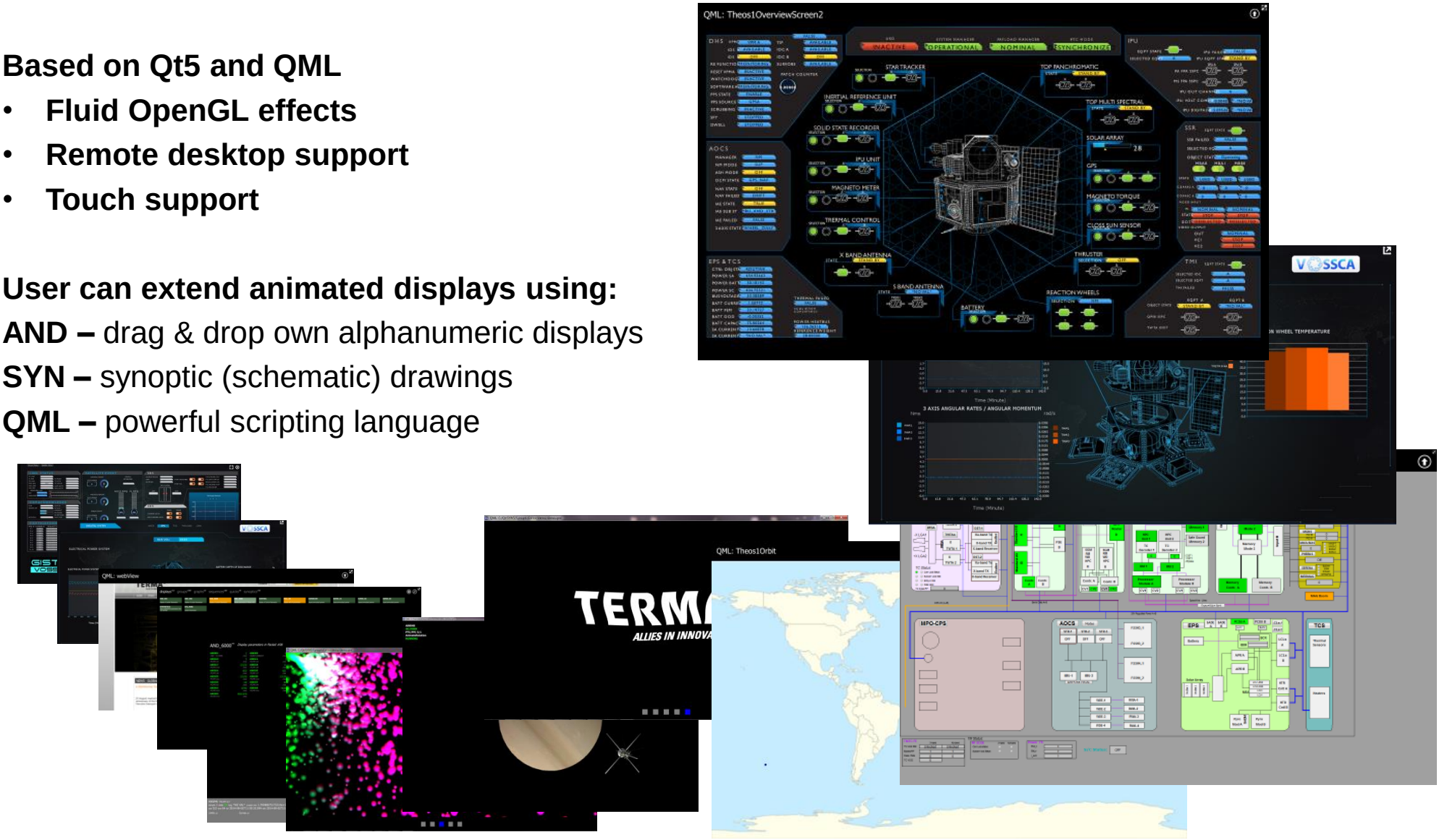
- **Fluid OpenGL effects**
- **Remote desktop support**
- **Touch support**

User can extend animated displays using:

AND – drag & drop own alphanumeric displays

SYN – synoptic (schematic) drawings

QML – powerful scripting language



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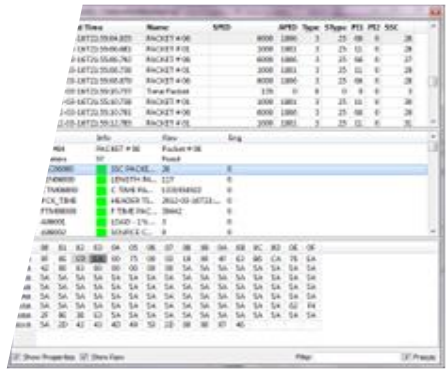
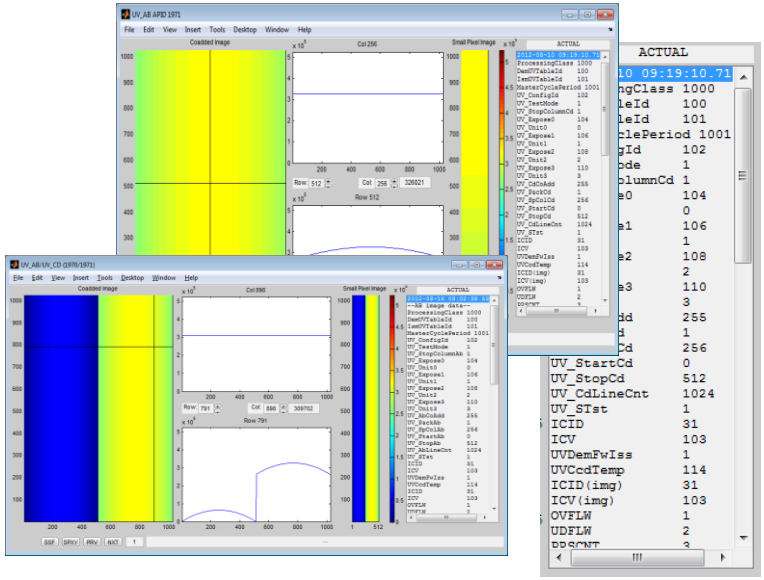
PERFORMANCE

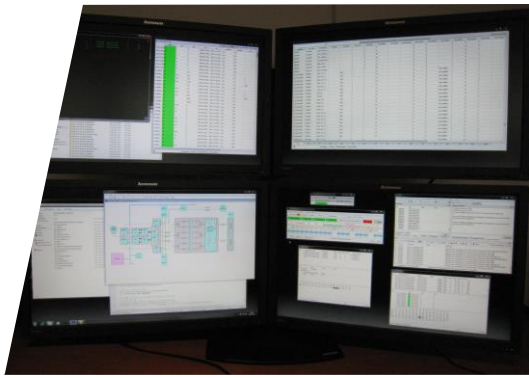


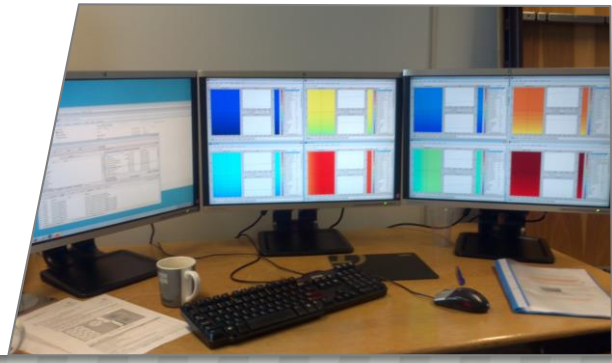
High data rates are used for

- **Low latency response (e.g. events from device)**
- **Fast replay & analysis (e.g. onboard mass memory replay)**
- **High rate spacecraft interfaces (e.g. SpaceWire)**
- **Simple science processing (e.g. Quick Look display)**
- **File transfer (e.g. CFDP)**

Integration with MATLAB…







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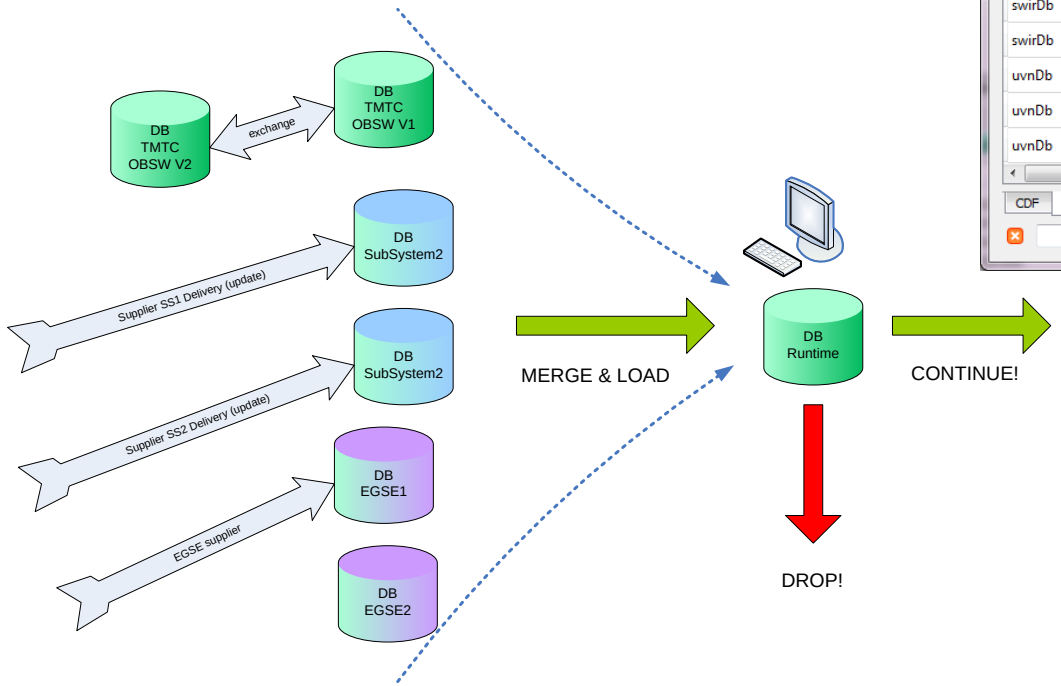
TMTC DATABASE (MIB)

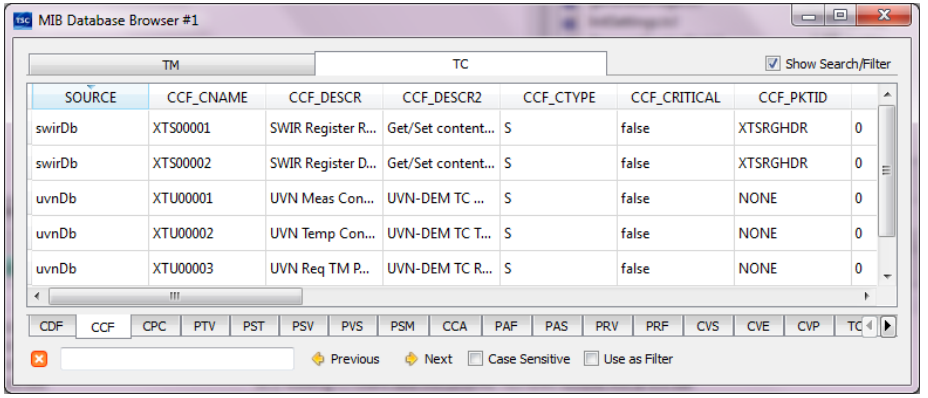
MIB databases are often defined by different suppliers

Merge from different sources (Platform, Payload, EGSE)

Drop / load / continue (no need to restart session)

Online access / view current MIB




MIB Database Browser #1
TM
TC
Show Search/Filter
SOURCE
CCF_CNAME
CCF_DESCR
CCF_DESCR2
CCF_CTYPE
CCF_CRITICAL
CCF_PKTID
swirDb XTS00001 SWIR Register R... Get/Set content... S false XTSRGHDR 0
swirDb XTS00002 SWIR Register D... Get/Set content... S false XTSRGHDR 0
uvnDb XTU00001 UVN Meas Con... UVN-DEM TC ... S false NONE 0
uvnDb XTU00002 UVN Temp Con... UVN-DEM TC T... S false NONE 0
uvnDb XTU00003 UVN Req TM P... UVN-DEM TC R... S false NONE 0
CDF CCF CPC PTV PST PSV PVS PSM CCA PAF PAS PRV PRF CVS CVE CVP TC
Previous
Next
Case Sensitive
Use as Filter

Flexibility:

- ***Frequent changes***
- ***Quick turnaround***
- ***Avoid manual work***

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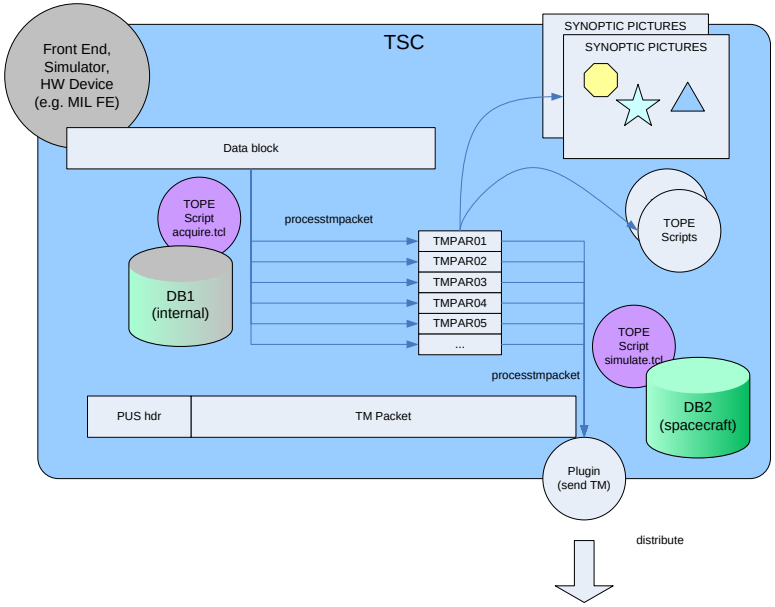
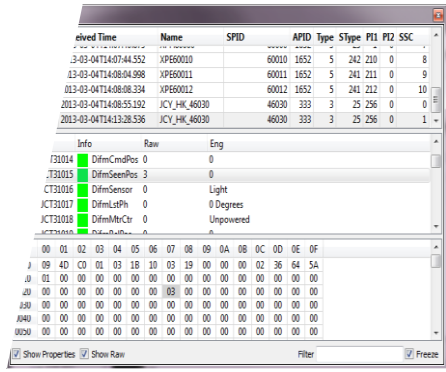
TM SIMULATION

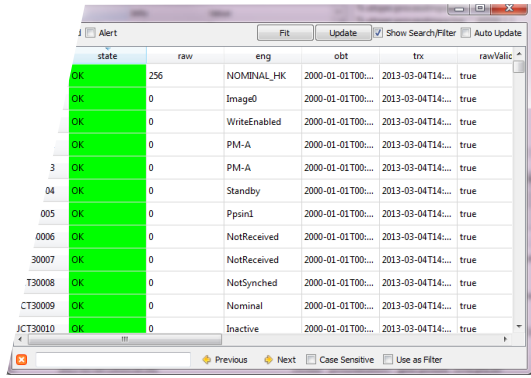
Allows:

- Local testing (e.g. check MIB, Synoptic Pictures)
- Data transformation from device inputs
- TM packet generation (e.g. SCOE or Spacecraft HK)
- Flexible (MIB can change)

Simply invert TM processing!







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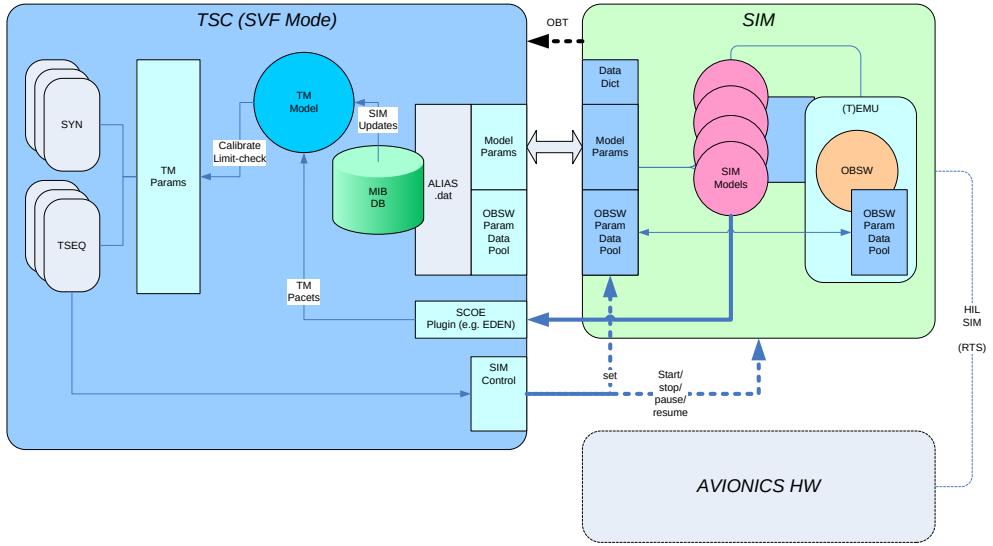
SIMULATORS & SVF MODE

Integrate different simulator platforms: e.g.

```
% package require eurosim
% package require SIMSAT
```



Note: simulated time is not always real time!

Onboard software may not be running in real onboard computer (i.e. **emulator**)

SVF mode allows "time" to

- **Pause**
- **Resume**
- **Speed up**
- **Slow down**

Command verification reacts correspondingly…

SVF allows flight software testing with or without real HW

Simulation:

- ***Real-time***
- ***Simulated-time***

Support SVF operation

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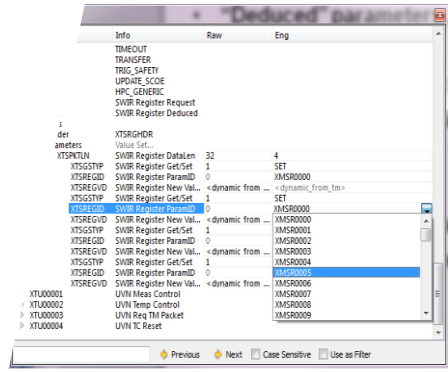
IMPROVED PUS SUPPORT

Historically, most TMTC packet definitions were static

SCOS2000 allowed some variability in packet definitions (e.g. VPD = nested groups of parameters)

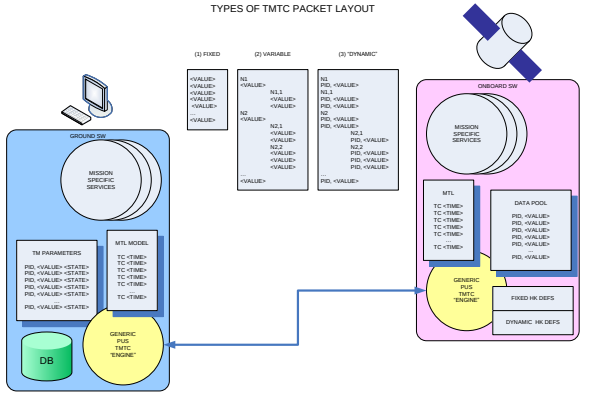
Primes using more advanced on board software

On board parameter data pool
Onboard monitoring services reference onboard parameter ID,
MIB defines“deduced” parameters, but SCOS2000 has many limitations in this area
Autonomous event-actions



Variable packets can be “self describing”:

- i.e. Nested “id / value” pairs….
- “Deduced” parameters, (ID comes from packet)



Improved support for Variable Packets

- Parameters from Variable Packets globally visible (SCOS2000 has only VPD)
- Deduced parameters in TC as well as TM (SCOS2000 has TM only)
- Repeat counters can be deduced from packet length, or (de)calibrated
- Introduce CDF_OFFSET as corollary to VPD_OFFSET, allows more flexible TC formatting, e.g. optional parameters

See “MIB Compatibility” section of the user manual

- Changes permitted if:
  - Justified –brings benefit that a real mission will use
  - Import compatible – files from SCOS2000 would still be accepted
- BUT: for export compatibility with SCOS2000, do not use these features

Improved support for current & near- future onboard software evolutions

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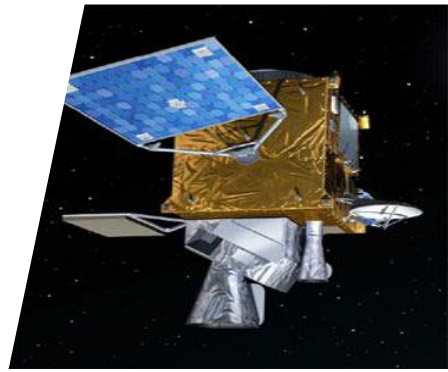
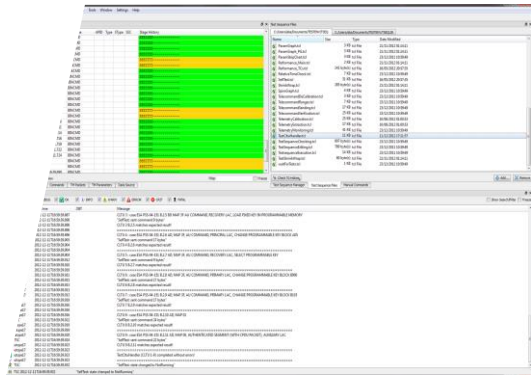
FRAMES SUPPORT





CCS & TSC also support TM/TC frames

Checkout systems were often packet-only
Follows ESA/ECSS/CCSDS TMTC standards

Telecommand CLTU generation

- Segmentation
- Aggregation (“blocking”)
- Authentication
- Randomization
- Control Frames
- BCH coding

Telemetry frame processing

- COP1 flow control

Suited for testing with

- Onboard Computer at frame level (e.g. umbilical)
- Operational Simulators at frame level

Note:

- Follows ESA / ECSS CCSDS customisation
- Assumes R-S, convolution in HW (if needed)

Frame-level access for operations and for hybrid test rigs

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GROUND SEGMENT FRONT END (GSFE)

- **Used for MCS and "hybrid" EGSE**

  A hybrid EGSE permits use of operations protocols in parallel with classic EGSE ones
  e.g. Interface to platform (or simulator) at frame level, interface to SCOE using packets
  Can be used in TSC as well as CCS

- **Interfaces at Frame / CLTU level**

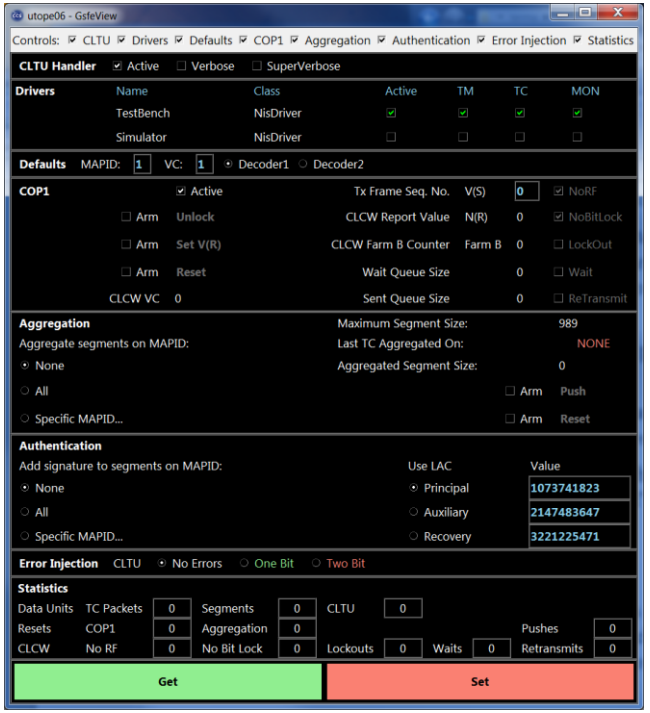
  Manages uplink verification stages

- **Generic core, extensible via "drivers"**

  Drivers are written in TOPE with [incr TCL} (object-oriented Tcl)
  System is delivered with standard and de-facto commercial standard drivers (e.g. CORTEX, NIS)
  Separate package (UNIS) is required to use SLE
  Source code of standard drivers is fully visible
  User could (for example) add a driver to support a new interface or simulator

- **Simple to configure**

  For very simple configurations (only one "ground station") configuration can be done when CCS is installed
  Settings hierarchy defines an arbitrary ground-station network (real-world scenarios) – one node per connection
  Arbitrary choice of driver for each defined ground network entity are either standard or custom
  Control is via the "GsfeView" user interface


utope06 - GsfeView
Controls: CLTU Drivers Defaults COP1 Aggregation Authentication Error Injection Statistics
CLTU Handler Active Verbose SuperVerbose
Drivers Name Class Active TM TC MON
TestBench NisDriver
Simulator NisDriver
Defaults MAPID: 1 VC: 1 Decoder1 Decoder2
COP1 Active Tx Frame Seq. No. V(S) 0 NoRF
Arm Unlock CLCW Report Value N(R) 0 NoBitLock
Arm Set V(R) CLCW Farm B Counter Farm B 0 LockOut
Arm Reset Wait Queue Size 0 Wait
CLCW VC 0 Sent Queue Size 0 ReTransmit
Aggregation
Aggregate segments on MAPID:
None
All
Specific MAPID...
Maximum Segment Size: 989
Last TC Aggregated On: NONE
Aggregated Segment Size: 0
Arm Push
Arm Reset
Authentication
Add signature to segments on MAPID:
None
All
Specific MAPID...
Use LAC
Principal
Auxiliary
Recovery
Value
1073741823
2147483647
3221225471
Error Injection CLTU No Errors One Bit Two Bit
Statistics
Data Units TC Packets 0 Segments 0 CLTU 0
Resets COP1 0 Aggregation 0 Pushes 0
CLCW No RF 0 No Bit Lock 0 Lockouts 0 Waits 0 Retransmits 0
Get
Set

GSFE manages a set of ground station interfaces at frame and CLTU level

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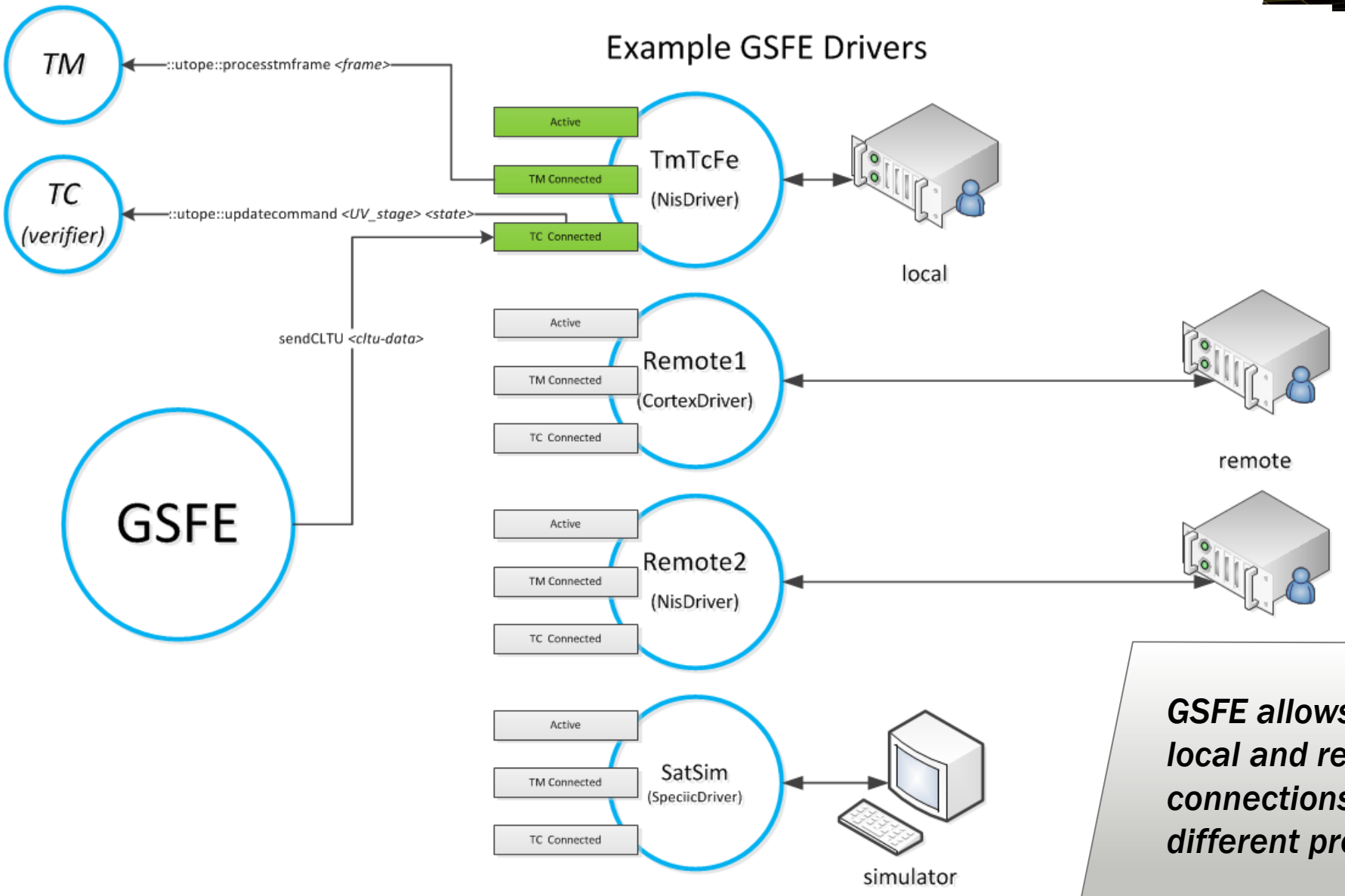
EXAMPLE DRIVER CONFIGURATION



GSFE allows mixed local and remote connections with different protocols

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HOT REDUNDANCY

For high-criticality scenarios

- **Mission Control**
- **Critical Tests (e.g. Thermal Vacuum)**

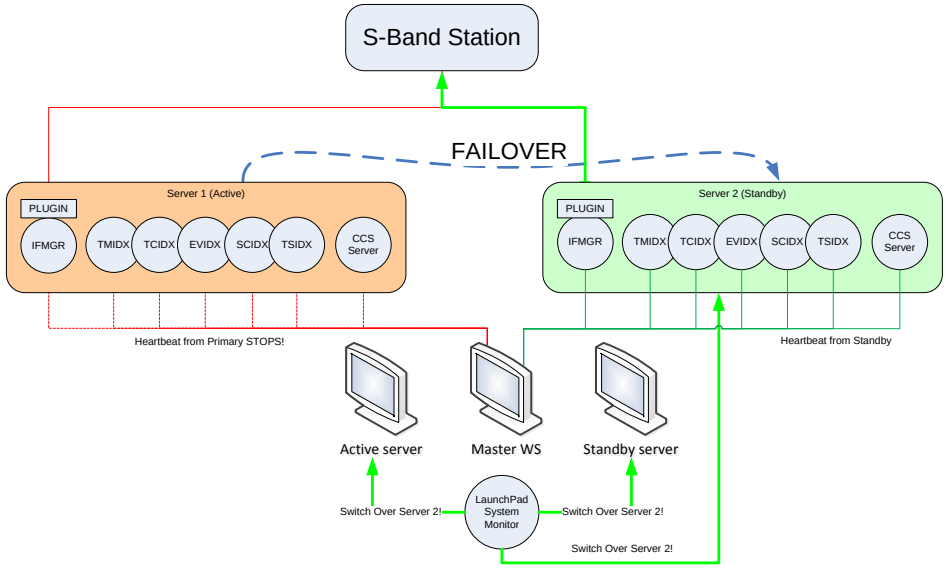
Simple concept:

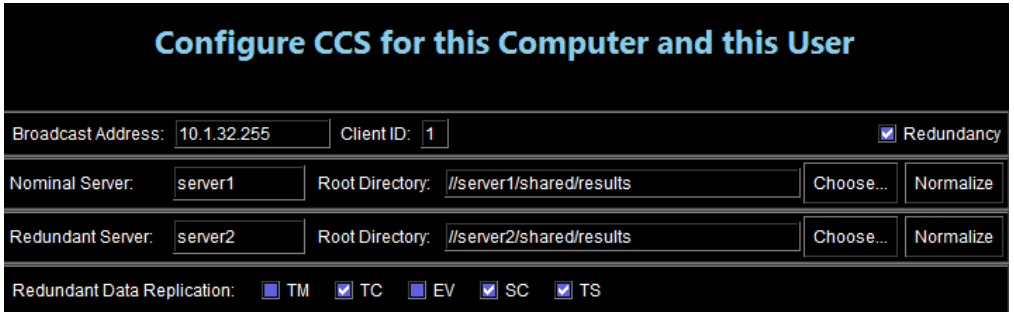
- **CCS server has a “sibling” redundant server**

  Very simple to configure
  If server fails, workstations can switch
  Failure status is displayed, and user has option to decide to switch (deliberately not automatic)

- **CCS Indexers (IDX) replicate data**

  Information archived in the primary is also archived in the redundant
  Typically (by default) TM is not replicated, because typically multiple TM links are supported – this can be configured
  TC (telecommand) history is replicated
  Command verification can transfer from primary to redundant server





Hot Redundancy allows fail-over to a standby server

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SUMMARY

Problem: legacy “big” systems were going out of date

Solution: new technology developed to the same interfaces

- Avoids major culture shocks – no new data model
- Realistic for near- and medium- term needs
- Major performance improvements
- Interesting functional improvements
- Flexible plugins (protocols and devices)

Compatible with historical systems:

- Database (MIB)
- Scripts (TOPE/ TCL/TK)

CCS – multi-user client-server system

- *Suitable for spacecraft testing*
- *Supports complete AIT team to collaborate*
- *Shared databases & results*
- *Full test session management*

TSC – single-user system

- *Suitable for Payload & Instrument testing & SCOE controllers*
- *Suited for high-performance direct device access*
- *Simplified session management*

Priorities

- *Quick to Install*
- *Familiar*
- *Adaptable*
- *High performance*
- *Affordable*

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